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(54) Abstract Title
Object tracking within a defined area

(57) In a method for tracking a number of objects within a defined area e.g players 12 on a football pitch 1, each object carries a device which transmits or reflects an ultra wide band (UWB), time modulated impulse radio signal and has a unique signature. Further devices 3 are located in or around the defined area 1 to receive radiation from the moving objects 12 and provide position information for each detected signature. A computing means is provided to determine, display and record the objects position within the defined area. The information may be used to control moveable apparatus such as cameras 6,7 or spotlights and may be used to provide positional information as a basis for game play adjudication. A further means may be provided for broadcasting and redisplaying positional information at a remote device.

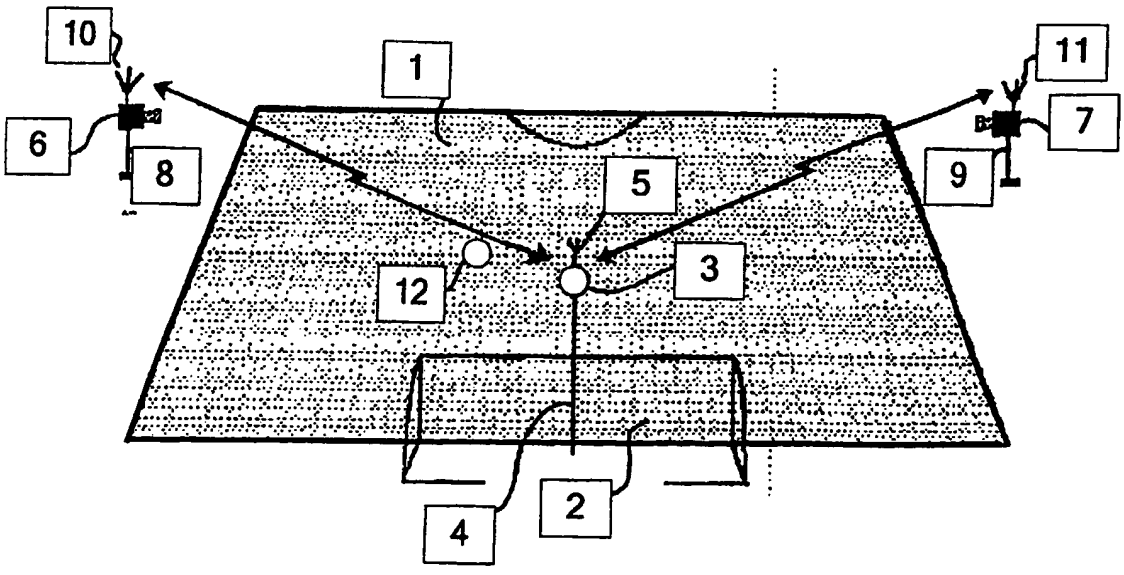

Figure 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

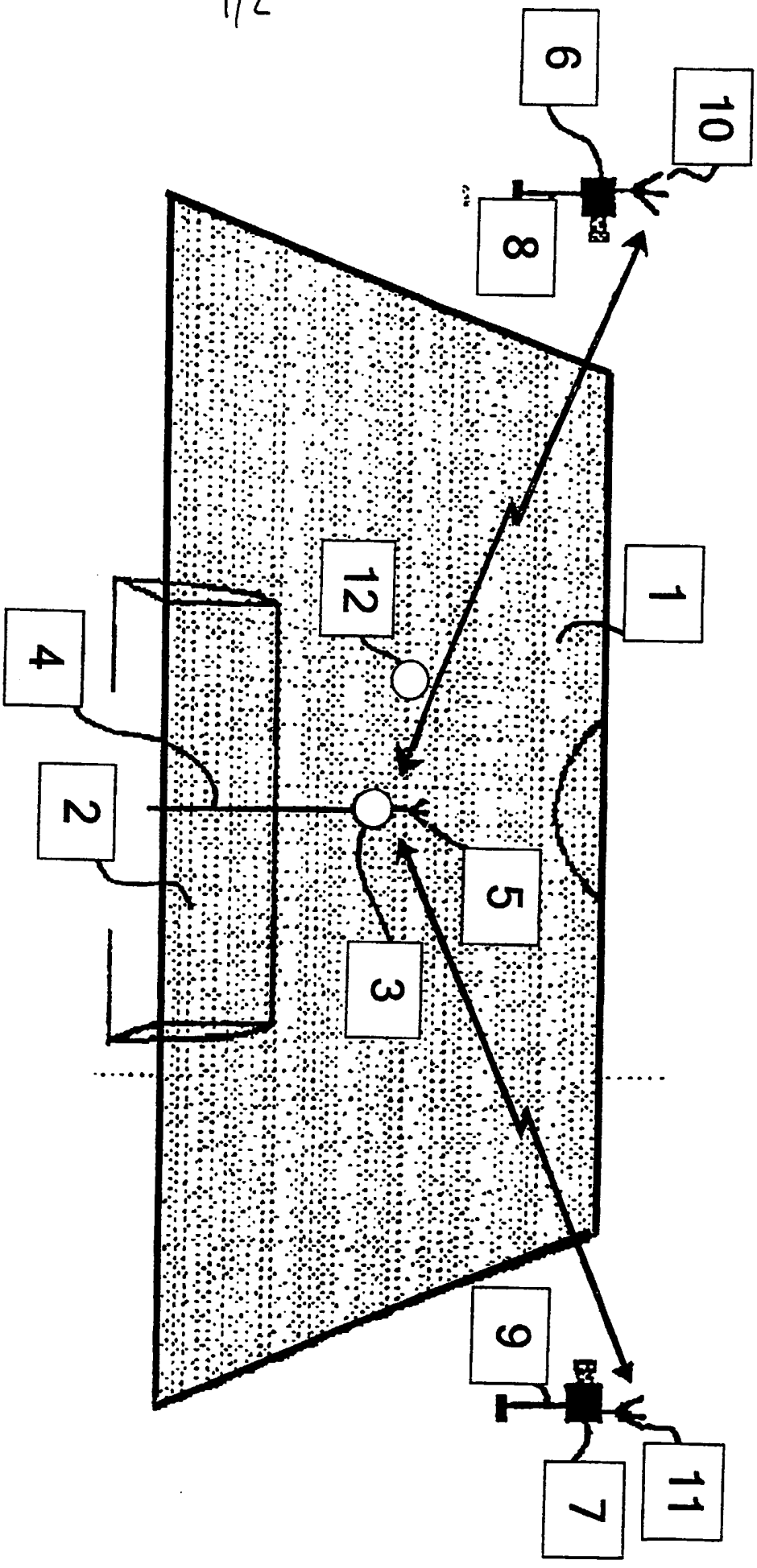

Figure 1

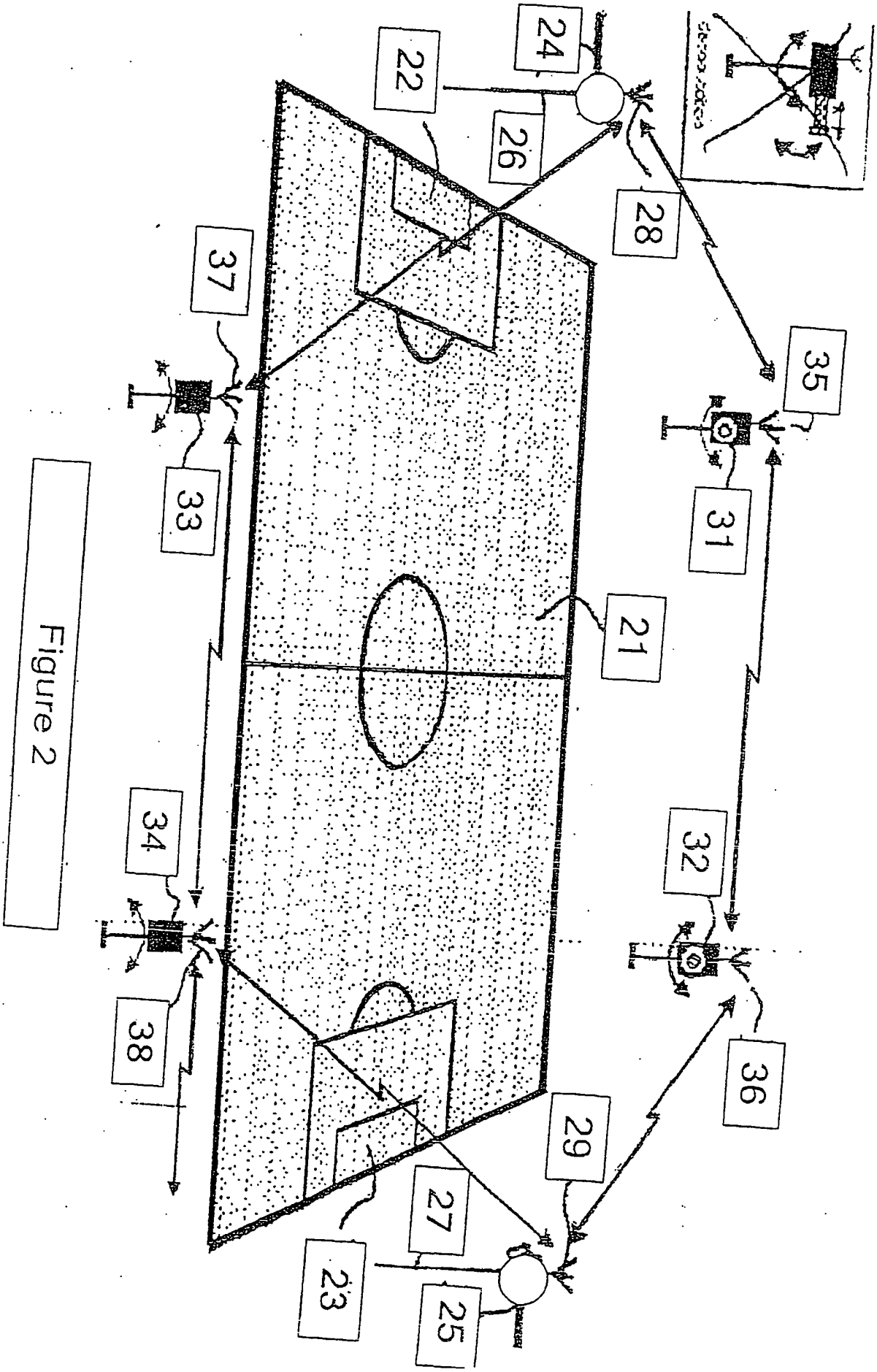

Figure 2

DATA ACQUISITION, OBJECT TRACKING AND CAMERA GUIDANCE SYSTEM

The visual recording, or, broadcasting of events, and especially sports events is frequently marred by the quality and/or the accuracy of the images captured for presentation to a viewer. Often the image from a manually operated camera will not follow in close up a player, horse, car or other moving object accurately. The object may be only partially shown, the image may be jerky or it may not show the most relevant object at the time of transmission. Indeed if camera operators are asked to concentrate on the close up image of a particular participant they may not even be able to identify that participant in a crowded scene. Broadcasting of such events, by transmission of image-data across existing telephony networks and/or via the Internet and other restricted-bandwidth networks has proven unsatisfactory due to the high bandwidth required to transport the large volumes of video information. This situation frequently leads to picture break up or such poor quality as to make the transmission un-viewable. Of separate concern is the quite typical occurrence in sports for disputes to arise between players and adjudicators over the precise facts of a particular incident, with snap decisions needing to be made - and which can often have severe consequences, but frequently must be made in the absence of definitive factual information.

The present invention is a data acquisition system that provides object tracking enabling each one of a plurality of participants in a sport, game or other populated action area to be tracked and which provides information enabling the precise 2- or 3-dimensional location of each participant within the action area to be established in real time (i.e. x,y or x,y,z Cartesian coordinate descriptions of an object's position in space, relative to a pre-determined origin, at a known point in time). The information may be used to command another device to robotically-track a selected participant, e.g. a camera, spotlight or other device, or the positional data may be recorded for subsequent analysis. This information can also be used in real time for transmission to local or remote locations, enabling dynamic graphical representations of the live event to be rendered, with a minimal time delay, similar to that experienced when viewing orthodox broadcasts via atmospheric transmission, cable or satellite.

Further benefit may be gained from the present invention as the object tracking system incorporates a method for transmitting digitally encoded information from the moving target, e.g. telemetry data such as

heart rate or fuel remaining, or indeed voice data, to the remote tracking station/s for processing and use by others.

Also, by including into the present invention a computer means that can be made aware of certain rules of the game, great benefit may derive from it now being possible to monitor the rules-compliance status for all participants, for any number of position-related games' rules, providing real-time adjudication decision-support information to match officials.

Summary of the Invention:

1) It is an object of this invention to provide a means for the collection of one or more tracked-object's unique ID, positional and voice/telemetry data within a defined action area.

2) It is another object of this invention to provide a means for the smooth accurate tracking of objects based upon the positional data gathered.

3) A further object of this invention is to provide a means to broadcast and redisplay the positional and other data gathered, for use by remote devices, e.g. for a PC or similar to render a virtual display of a live event.

4) Another object of this invention is to provide the means for a real-time game play adjudication decision-support system.

According to the present invention there is provided a system and method for tracking one or more moving objects and regularly recording their position in real-time. System utilises a plurality of ultra wideband, time-modulated impulse radio transmitters and transceivers, and employs suitable data-communications and positioning algorithms coupled with a computing means to determine, display and record a target's position and voice/telemetry data. The information may be used to control one or more cameras, spotlights or like apparatus. It can also be used to enable the production of virtual television, the provision of performance information for interactive television, positional information as a basis for the creation of certain types of computer games and performance and statistical information for sports training programmes.

Description of the Preferred Embodiment:

In the preferred embodiment the radiation emitting or responsive marker device (Squawker®) emits and/or is responsive to Ultra wideband (UWB) microwave radio radiation and is located wherever upon the object will most likely provide a substantially unobstructed view between that part of the object, and the radio

communications base stations (iTelliNodes), in a given application context. If the orientation of the obje is desired in addition to its position, then the object will have two Squawkers® attached - one on either flank The signature is preferably provided by a pulse-train of time code modulated short Gaussian monocycles in a form of pulse-position modulation in which the value of each instantaneous sample of a modulating signal is caused to modulate the position in time of a pulse (see US Pats 6,300,903, 6,297,773, 6,295,019, 6,133,876, 6,111,536 , 6,031,862, 5,995,534, 5,969,663, 5,963,581, 5,960,031, 5,952,956). The marker devices preferably emit and are responsive to radiation in the region 1.0 Ghz to 10 Ghz, and operate at extremely low power levels, and relatively short ranges.

The position sensors (iTelliNodes™), like the Squawkers®, are preferably devices which transceive millions of low power coded pulses per second across an Ultra wideband of the radio spectrum, enabling high-speed and high performance for communications, radar, and precise positioning/tracking. iTelliNodes™ are thus able to exchange similarly-coded messages emitted from the Squawker® device/s, as well as other iTelliNodes™. Preferred iTellinode devices are UWB transceivers sensitive to pulse-time coded modulation spread across the spectrum. In either case the sensor should have a high sensitivity between 1.0 Ghz and 10 Ghz frequency range, and operate at extremely low power levels, and relatively short ranges. Signals are transceived between iTelliNodes™ and from Squawkers® across all or part of the action area.

Scanning the area within range for Squawkers® emissions provides information that can be used by the computer with the means to calculate the two and three-dimensional location of each detected object. The computer means enables the information for a particular Squawker® from one or more of the iTelliNodes™ to be correlated to provide a series of outputs each corresponding to the position-measurement of a single object (Squawker) within the action area at a moment in time. The scanning rate is preferably rapid enough to provide smooth motional information. A variety of different positioning algorithms are envisaged, such as Angle of Arrival; Time Difference of Arrival etc.

The output of each iTellinode is corrected (using the approx half dozen prior manual physical-calibration measures taken within the action area) to give Cartesian or polar co ordinates for each object within the cubic-space that is the defined action area. The identity of each object is determined on the basis of its radiated pulse-coded signature. In a preferred embodiment the information is processed to provide time-

stamped X, Y and Z-axis coordinates in digitally coded form for each unique Squawker®. At the same time, and in the same manner, as the identity data is digitally encoded, transmitted, and digitally decoded from each target to a listening base station, so telemetry and/or voice data could also be transferred. The iTelliNodes™ may be chosen for their small size and weight so that they can be located on poles, towers or buildings according to the nature of the location of the action area. The computer means may comprise a single microcomputer or a series of microcomputers in different locations. Communication between the iTelliNodes™ and the computer means may be by cable, optical fibre or radio link.

The position, identification and other information provided by the computer means may be stored to provide an accurate record of the movements of the objects over a period of time. Alternatively or as well, the information may be provided to a robotic position control means (Coolhead®) associated with a camera, spotlight or other device that requires directional control. In this manner a camera mounted upon a Coolhead® may be instructed to follow a particular object, e.g. a football player or a racing car, without reliance on the visual and manual skills of a human operator. It is possible to calculate the distance of the selected object from the camera from the positional information already gathered, so that the object can be maintained in focus by the camera automatically. Further, by use of this distance information, in conjunction with predefined in-field reference-measures, a viable means now exists for automatic zoom compensation control of a camera lens.

The computer means may also be used to forward digital data across a Wide Area Network (WAN) such as the Internet or similar, for the purposes of providing a 'data-feed' of the live event's object-position data to a plurality of remote devices e.g. PCs, in order that they may use it to render a virtual representation of the remote live event, instead of or in addition to traditional broadcast pictures. The relatively tiny size of the data required to be transmitted in this innovation means that high-bandwidth network connections between the live and remote locations are not required for successful virtual viewing to occur.

The ability to derive real-time positional data for objects, coupled to the wireless communications nature of the preferred embodiment make the present invention ideal for the provision of a game play-adjudication system for match officials. Empowering referees and others with an independent, verifiable, accurate and automated system that can impartially determine if - and by whom - any number of rules of

the game have been broken, e.g. in a soccer context, was player X off-side ? Did the football cross th goal-line ? will bring a new level of correctness to the field of fair-play.

Brief Description of Drawings:

In order that the invention may be clearly understood it will now be described, with reference to the accompanying drawings, in which:

Figure 1 shows a position sensor (iTelliNode™) located at one goal of a football pitch controlling two cameras, and

Figure 2 shows a pair of iTelliNodes™ located at each goal of a football pitch controlling four video cameras positioned around the playing action area.

An action area comprising a half a football pitch 1, see Figure 1, has a goal area 2 above which is located an iTelliNode™ 3 mounted on a pole 4. The iTelliNode™ 3 includes data transmission means that are linked using either cable (not shown) or radio signals through the aerial 5. On each side of the pitch 1 are located television camera 6 and 7 mounted on poles 8 and 9. Control signals to the cameras 6 and 7 originate from a computer base station (not shown) relayed by a cable or radio link via aerials 10 and 11 to a Coolhead® incorporated in each camera platform.

Each camera platform 6 and 7, incorporates a Coolhead® that is capable of positional control command signals based upon position data derived by the computing means, itself based on measures resulting from the iTelliNode™ 3 scans. The Coolhead® orients, focuses and zooms the lens of its associated camera. A single player 12 is shown on the pitch 1.

The player 12 carries an UWB time-modulated pulse-coded marker (Squawker®) not shown that radiates (in either transceiving or transmit-only modes, and in either active or passive configurations) a coded signal. The iTelliNode™ 3 regularly scans the area of the pitch 1 and on each scan that it detects the player 12 it provides positional information related to the position of the player 12 within the action area. The positional information is processed by computer means (not shown) to provide signals relating to the X, Y and Z coordinates of the action area. These positional signals are sent to either or both of the Coolheads® 6 and 7 as control signals enabling them to be directed to and focussed on the player 12. The Coolhead® is able to direct the camera axis in both azimuth and elevation. Further controls allow the

effective focal length of the lens to be changed, zooming, and also enable the lens to be brought into focus on the player 12 on the basis of the distance calculated by the computer means. The choice of focal length is not an automatic function and is decided by a programme editor.

Another action area comprising of a complete football pitch 21, see Figure 2, has goal areas 22 and 23 above each of which are located iTelliNodes™ 24 and 25 mounted on poles 26 and 27. The sensors 24 and 25 include data transmission means linked either by cable (not shown) or radio through aerials 28 and 29. On each side of the pitch 21 are located television cameras 31, 32, 33 and 34 mounted on poles. Control signals to the cameras 31, 32, 33 and 34 originate from a base station (not shown) relayed by a cable or radio link via aerials 35, 36, 37 and 38 to Coolheads® on each camera platform. These computers relay information to the Coolhead® which orients, focuses and zooms the lens of the camera.

As described with respect to Figure 1, the iTelliNodes™ 24 and 25 provide locations and identification information for each player on the pitch 21 provided he/she is carrying a functional Squawker®. It is also possible for a ball (or similar object) to carry a Squawker® internally. The programme editor will have one or more overall views of the pitch 21 and can arrange for one or more of the cameras 31 to 34 to follow selected players in accordance with the position calculated on the basis of the information from the iTelliNodes™ 24 and 25.

In order that the camera motion control is smooth the effective object-position sampling rate used to obtain regular positional information must be rapid. Using the proposed UWB Time Modulated Pulse-Coded method, sensor read-out data can be achieved of up to one kilohertz.

In similar fashion, a lighting unit could be mounted on a Coolhead® , and in the same manner be directed to point at a dynamically selected tracked object.

By the addition of extra sensors, e.g. a pulse-rate monitor or a microphone/speaker arrangement, and their interconnection with a Squawker® aboard the object, it would be possible to collect and transmit additional object-specific data, e.g. heart rate, 1 & 2-way voice traffic to and from the Squawkers® and the iTelliNodes™/computing means.

CLAIMS

1. A method of tracking a plurality of moving objects within a defined action area such as a sports arena wherein each object carries an active or passive marker device (Squawker®) which either transmits or reflects an Ultra Wideband (UWB) pulse-coded time-modulated radio signal, having a unique signature. One or more position sensor devices (iTelliNodes™) are located in and around the action area and are arranged in combination to receive radiation from the moving objects and to provide position information for each detected signature, and computing means adapted to provide an output for each object indicating its position within the action area.
2. The method as claimed in claim 1, characterised in that the radiation emitting or responsive marker device emits or is responsive to Ultra Wideband radio frequency radiation, and is located wherever on the object will provide a substantially unobstructed view by the position sensors
3. The method as claimed in claim 1 or claim 2, characterised in that the signature is provided by pulse coded time- modulation of the emitted radiation from the marker device
4. The method as claimed in either of the claims 2 or 3, characterised in that the marker devices emit radiation in the region of 1 Ghz (Gigahertz) through to 10 Ghz.
5. The method as claimed in any of the preceding claims, characterised in that the position sensors are devices containing a multi-component Ultra Wideband radio transceiver sensitive to the radiation emitted from the marker device and able to demodulate and identify the position and unique ID associated with each object's marker device from all or part of the action area.
6. The method as claimed in any of the preceding claims, characterised in that the position sensor devices are radio transceivers sensitive to Ultra Wideband Time-modulated pulse-coded radio frequency emissions.
7. The method as claimed in any of the preceding claims, characterised in that sensor devices have a high sensitivity in the region 1 Ghz to 10 Ghz.
8. The method as claimed in any preceding claims, characterised in that the computer means (Eyrie) enables the information from all the position sensors to be correlated to provide a series of outputs each corresponding to the position of a single object within the action area at a moment in time.
9. The method as claimed in any preceding claims, characterised in that the output of each position sensor is Corrected to provide Cartesian or polar coordinates for each object within the arena.

10. The method as claimed in claim 9, characterised in that the output of each position sensor is processed to provide X, Y, and Z axis coordinates in digitally coded form.
11. The method as claimed in any of the preceding claims characterised in that communication between the position sensors and the computer means is by cable or radio link.
12. The method as claimed in any of the preceding claims, characterised in that the position and identification Information provided by the computer means is stored to provide a record of the movements of the objects over a period in time.
13. The method as claimed in any of the preceding claims, characterised in that the position and identification Information is provided to position control means associated with a device that requires directional control.
14. The method as claimed in any of the preceding claims, characterised in that the position and identification Information is provided to broadcast and redisplay the positional and other data gathered, for use by remote viewing devices, e.g. for a PC or similar to render a graphical virtual display of a live event.
15. The method as claimed in any of the preceding claims, characterised in that the position and identification Information is provided for a real-time game play adjudication decision-support system, including integrated 1-way and 2-way UWB RF (voice) communications.
16. The method as claimed in any of the preceding claims, characterised in that the UWB RF link method provides for a secure telemetry between sensors on objects, passing gathered data via the marker device emissions to be received by the position sensors in the same manner as the positional data signals.
17. Methods of tracking a plurality of moving objects within an action area s claimed in claim 1 and as herein described.
18. Methods of tracking a plurality of moving objects within an action area as herein described with reference to the accompanying drawings.

Application No: GB 0207512.5 **Examiner:** Richard Kerslake
Claims searched: 1-18 **Date of search:** 18 December 2002

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1-12 15 & 16	GB 2348757 A	(CHAUDHRY) Figure 1 & Abstract
X	1-12 15 & 16	GB 2339504 A	(MURRAY) See Whole Document
X	1-12 15 & 16	GB 2337385 A	(LYDEN et al.) See Whole Document
X	1-14	WO 98/37932 A1	(TRAKUS) Page 5 Lines 12-29, Page 9 Lines 28-29 & Page 17 Lines 25-26
X	1-12 15 & 16	FR 2753633 A	(VIENNOT) Figure 1 & WPI Abstract
X	1-12 15 & 16	FR 2726370 A	(VALLORTIGARA) Figure 2 & WPI Abstract
X	1-12 15 & 16	FR 2711069 A	(THIERRY) Figure 1 & WPI Abstract
X	1-12	FR 2679146 A	(DAVER) Figure 1 & WPI Abstract
X	1-13 & 17	DatAcq. "The science of instant positional information". Retrieved from the internet http://www.datacq.com/	

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

H4D

Worldwide search of patent documents classified in the following areas of the IPC[7] :

G01S

The following online and other databases have been used in the preparation of this search report :

EPODOC, JAPIO, WPI, Selected Publications